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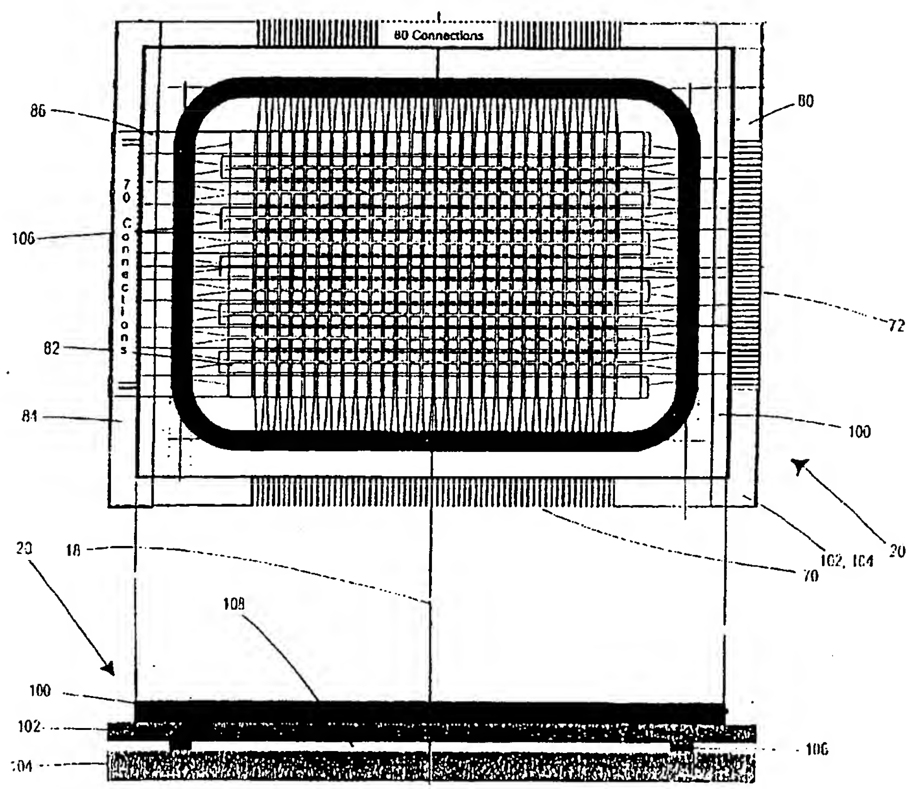
(54) **COMMANDE DE DENSITE LUMINEUSE ET ARRANGEMENT D'ACL**

(54) **LIGHT DENSITY CONTROL WITH LCD ARRANGEMENT**



(57) The invention relates to an LCD arrangement, especially for the illumination control of an exposure arrangement, such as a photographic printer for the exposure of photo-sensitive material, with a first transparent plate (102) and a second transparent plate (104), which are planar and positioned spaced apart parallel, whereby a liquid crystal fluid is enclosed in a space between the plates (102, 104), whereby the LCD arrangement includes multiple picture elements (pixels) associated with electrodes which are positioned on the plates, whereby feed conductors to the electrodes feed control signals thereto, whereby, the first plate on one side has a picture element associated with an electrode, while the feed conductors associated with an electrode are provided on the other side of the first plate (102) and the respective feed conductors are connected to the electrodes (74) through conductive regions in the first plate.

ABSTRACT

The invention relates to an LCD arrangement, especially for the illumination control of an exposure arrangement, such as a photographic printer for the exposure of photo-sensitive material, with a first transparent plate (102) and a second transparent plate (104), which are planar and positioned spaced apart parallel, whereby a liquid crystal fluid is enclosed in a space between the plates (102, 104), whereby the LCD arrangement includes multiple picture elements (pixels) associated with electrodes which are positioned on the plates, whereby feed conductors to the electrodes feed control signals thereto, whereby, the first plate on one side has a picture element associated with an electrode, while the feed conductors associated with an electrode are provided on the other side of the first plate (102) and the respective feed conductors are connected to the electrodes (74) through conductive regions in the first plate.

LIGHT DENSITY CONTROL WITH LCD ARRANGEMENT

Field Of The Invention

The invention relates to the field of photo finishing and in particular the field of light density control by way of a LCD arrangement, whereby a photographic negative or the like is scanned in order to determine the light density profile thereof and to carry out, based on this determination, a masking of the negative with a LCD arrangement. Regions which are too dark can be brightened this way, while bright regions, or regions with advantageous density distribution remain intact, in that the LCD arrangement delivers an appropriate masking to produce a photographic print with optimized exposure. The present invention hereby especially relates to a LCD arrangement which is constructed for the said purposes as well as a process for its manufacture.

Background Art

Various types of arrangements and processes have been disclosed in the prior art for the manipulation of the light density during exposure of photographic prints. U.S. 3,925,520 shows a system for contrast control during manufacture of photographic prints. A negative is scanned and, based on an analysis of the data obtained during scanning, a matrix of transparent ferro-electric ceramic material is manipulated such that a correction of the exposure can take place in order to improve the quality of the prints.

An arrangement is also known from DE 28 20 965 which uses a LCD matrix in order to enable a correction so that a light density control of the type can be carried out wherein regions of a negative that are too dark or too light can be equalized on the print.

DE 40 22 055 C2 similarly discloses an arrangement for colour and brightness control wherein a LCD matrix is employed to evenly modulate the three base colours red, blue and green depending on the requirements of a negative.

EP 0 315 589 B1 also employs a LCD matrix to control the light density.

Similar uses of a LCD matrix can also be derived from DE 196 34 148 C1, DE 196 18 476 A1, DE 41 03 905 A1 and other documents in the prior art.

The known arrangements or processes all employ arrangements which have a light yield that is comparatively minimal. Light yields of at most about 20% of the original light intensity provided by a light source can be achieved thereby. It is here therefore necessary to supply enormous light quantities to the LCD matrix, by significantly enlarging or boosting the intended light sources, or by enormously prolonging the exposure time. The first method in a corresponding arrangement results in the generation of large amounts of heat which must be removed, while the other method requires that the exposure time per print be increased at least five times.

Both are of little advantage so that it is an object of the present invention to provide a LCD arrangement for exposure arrangements in the field of photo finishing, which allows for the passage of significantly more light, whereby simultaneously no further impairments occur in the light path of the exposure arrangement.

Summary Of The Invention

These advantages are achieved with the preferred LCD arrangement according to the present invention especially for the exposure control of an exposure arrangement, such as a photographic printer, for the exposure of photosensitive material, with a first transparent plate and a second transparent plate which are planar and positioned spaced apart parallel; a liquid crystal fluid which is enclosed between the plates; a plurality of picture elements (pixels); electrodes provided on the first and second plates and associated with the picture elements; feed conductors for feeding control signals to the electrodes; the electrodes associated with the picture elements being located on one side of the first plate; the feed conductors associated with the electrodes being located on the other side of the first plate; and the respective feed conductors being connected with the electrodes

through conductive regions in the first plate.

Simultaneously, it is an object of the present invention to provide a process for the manufacture of a LCD arrangement in accordance with the invention.

A preferred process for the manufacture of an LCD arrangement according to claim 1, including the steps of providing the first plate with an opening mask for defining the conductive regions; subjecting the first plate to a material removing treatment for producing the openings in the first plate; applying a material which in the visible light spectrum is essentially transparent to both sides of the first plate; structuring the conductive, transparent material for forming at least one of the feed conductors and the electrodes; fastening the second plate planar and spaced apart parallel to the first plate; and filling an intermediate space between the plates with the liquid crystal fluid.

According to the invention, a LCD arrangement for the exposure of photo sensitive material includes a first transparent plate and a second transparent plate, which are planar and spaced apart parallel to one another. A liquid crystal fluid is placed between the plates so that it can not escape from the intermediate space between the plates. At least one of the plates includes electrodes which can be supplied with control signals through feed conductors. In such a LCD arrangement, the first plate on a first side includes an electrode associated with a picture element (pixel), whereby the signal feed conductor for the electrode is provided on the side opposite the first side of the first plate and whereby the electrode is connected with its associated feed conductor through a conductive region in the first plate.

It is thereby possible according to the invention to make the active surface of the individual picture elements exceptionally large, since no space must be spared for conductors connecting the electrodes of the picture elements with the feed conductors of the LCD arrangement. In this manner, a space between the electrodes of the picture elements is only required to prevent cross talk or short

circuiting between the electrodes or the picture elements. Otherwise, if the feed conductors, as common in the prior art, were positioned on the same side as the electrodes of the picture elements, first, sufficient space would have to be provided also for the various feed conductors on the same side of a transparent plate and, second, respectively sufficient spacing would have to be provided between the various feed conductors and the electrodes. In this manner, the active matrix surface of the LCD arrangement would become so coarse that the structure of the LCD arrangement would be visible on the photographic paper upon exposure. Furthermore, such a reduction of the active surface causes a corresponding reduction in the achievable light intensity modulation. This is avoided in accordance with the invention.

Counter electrodes, separate from the electrodes are provided on the second transparent plate, as is known in principle. Between the electrode planes, the space with the liquid crystal fluid is provided for the generation of an electrical field to achieve a correlation or percolation among the crystal components of the liquid crystal fluids. Good results have been achieved when openings were formed in the first plate for the conductive regions, the edges or walls of which were at least partly covered or coated with a conductive material. The openings in the first plate can thereby be provided, for example, with a photographic mask and wet or dry etching techniques. A photo lacquer mask can be applied to the first plate for the formation of openings, which is insensitive to hydrofluoric acid. An etching with hydrofluoric acid then leads to the formation of openings, the edges or walls of which can then be coated with a conductive material by conventional techniques.

Especial advantages result when the electrodes or counter electrodes are made of a material which at least in the visible range of light is at least essentially transparent. It is also possible to form the electrodes and counter electrodes as conductor frames which surround the picture element regions or net-like cover them, however, such electrodes would lead to the generation of dispersion effects or the pattern of the LCD arrangement would be apparent on a print. Such a solution would also be

associated with light loss and a reduced degree of modulation.

Accordingly, at least one of the feed conductors or feed conductor planes, which are associated with the electrodes or counter electrodes are manufactured from a material which is at least essentially transparent at least in the visible range of light. The same goes for the coating which within the openings in the first plate forms the conducting regions or passages.

A transparent material which can also be made conductive is ITO (indium tin oxide). This material can be applied evenly thin on a surface with conventional techniques, structured, and employed as a conductor which at the same time is essentially transparent for visible light.

It has been found especially advantageous when the transparent plates of the LCD arrangement in accordance with the invention are provided with a light or radiation sensitive additive, preferably a silver-containing additive, so that the conductive regions or openings can be produced with appropriate treatment. Correspondingly, transparent plates of glass are thereby provided with a mask which corresponds with the opening pattern for the formation of the conductive regions. An illumination or irradiation through the mask structure follows so that the condition of the regions including the silver-containing additive which can be irradiated through the openings in the mask structure is changed in order to be then especially sensitive to a structure etching. The FOTURAN® (registered mark) glass of the company Schott has proven especially advantageous. This material is a photo sensitive material which can be selectively structured in different ways. One starts thereby with a photo structuring. A mask is applied to the photo sensitive glass. The masked glass is subjected to UV irradiation, whereby the regions not covered by the mask react photo chemically. Subsequently, the mask is removed and the glass tempered. Finally, an etching with hydrofluoric acid or the like is carried out, which provides an especially advantageous hole structure. Because of the relatively sharply defined irradiation, the subsequent etching produces holes or openings with relatively sharp

and even edges, whereby advantageously absolutely no under-etching takes place. Accordingly, the edges or walls of the openings can be coated relatively well, for example, with the above discussed ITO coating.

Alternatively, it is also possible to equip the first transparent plate, for example, with the conducting regions. A masking of the first plate could hereby also take place whereby material could subsequently be introduced selectively into the first transparent plate to form the conductive regions, by way of a thermal doping or by way of a bombardment with conductive particles in an accelerator.

In order to be able to guarantee the most even surface covering, the feed conductors should have as large an area as possible. Furthermore, the electrodes and counter electrodes respectively should have as large a surface area as possible. By forming the electrodes, the feed conductors to the electrodes, the counter electrodes, and the feed conductors to the counter electrodes with a large surface, it can be guaranteed that the light passing through the light path of an exposure arrangement is treated evenly, so that a disadvantageous influencing of the exposure process is avoided. The electrical resistance of the feed conductors becomes smaller with the larger surface.

When openings are provided in the first plate for connection of the feed conductors to the electrodes, the regular hole structure influences the light during an exposure process. In order to reduce this effect as much as possible, the openings are filled, as much as possible, with a largely transparent filler material, such as a synthetic resin, a putty or the like preferably air free, or without gas enclosures. This is also necessary so that the liquid crystal remains encased.

In order to avoid a negative influence of the light spectrum of a light source in an exposure arrangement on the LCD arrangement according to the invention and especially its liquid crystal fluid, the LCD arrangement can be provided in accordance with the invention with a UV protection. The UV protection is applied to

at least one of the plates. To prevent reflections, a UV protection can also be applied to both plates of the LCD arrangement, namely when components of the LCD arrangement in accordance with the invention are particularly UV sensitive.

In order to reduce the number of connections to the LCD arrangement in accordance with the invention, respectively two counter electrodes of two adjacent picture elements are supplied through a common feed conductor with signals, especially AC signals (duplex operation). It must thereby be considered that it is especially preferred to equip the LCD arrangement in accordance with the invention with PDLC as liquid crystal fluid, which cannot be exposed to direct current components, since PDLC (Polymer Dispersed Liquid Crystal) components are affected or destroyed by direct current, as are most other materials for LCDs. Accordingly, it is preferred according to the present invention to provide the LCD arrangement with features according to the invention with a PDLC material as liquid crystal fluid. With regard to the PDLC materials, reference is made to Hikmet R.A.M.: "Electrically induced scattering from anisotropic gels", J. Appl. Phys., Vol. 68 Nr. 9, pages 4406-4412, November 1990, whereby the content thereof is expressly made part of the content of the present disclosure. Individual substances or several of the PDLC substances disclosed therein, also in combination, are incorporated into the present disclosure.

A multiplex operation for the LCD arrangement with features according to the invention is of course also possible, but a duplex operation is preferred, whereby a combination of two respectively adjacent picture elements takes place, whereby two systems of counter electrodes with combined picture elements are used which are controlled with different, for example, complementary signals, for the reduction of the required connections and feed conduits.

In order to guarantee an especially advantageous control of the picture elements of the LCD arrangement in accordance with the invention, they should be constructed in such a way that they can be supplied with binary AC signals. It is important that

the voltage difference present across the LC (liquid crystal) is mean value free. Of course, alternating analog signals can also be used here for the control. It is thereby preferred to place signals on the electrodes of the picture elements or the feed conductors which in the transparent condition of the picture elements essentially average out over time or add up to an electric field, the effective value of which is essentially zero or lies below the percolation or correlation limit of the liquid crystal fluid. Otherwise, it is preferred to place signals on the electrodes of the picture elements or their feed conductors which in the non-transparent or light reflecting and/or absorbing condition average out over time or add up to an electric field, the effective value of which is above the percolation or correlation limit of the liquid crystal fluid. With regard to the PDLC materials it is thereby essential that the signals, as already mentioned, are alternating or AC signals. Direct current, or direct voltage components in the control signals for the electrodes of the picture elements are however to be avoided as much as possible.

An especially preferred process, also in view of its simplicity, consists in placing signals on the electrodes of the picture elements which either average out or add up such that the picture elements are transparent, or such that they are not transparent, whereby an amount of light to be passed through per picture element is adjusted over that time over which the picture element is not scattering or scattering.

In order to take into consideration different colour sensitivities of a print material to be exposed, each of the colour ranges for which print material to be exposed has a specific sensitivity can preferably be considered separately, whereby preferably a colour selective filter arrangement is employed. Colour filters can thereby be moved into the light path of the exposure arrangement and for each of the filters an exposure can respectively be carried out, whereby different picture elements can be maintained transparent or non-transparent over specific times, which means for example maintained scattering or non-scattering within a specific temporal relationship.

The process in accordance with the invention for the manufacture of a LCD arrangement with the above listed advantages is based on the following steps: First, a plate, or the first plate, preferably of transparent material, especially FOTURAN®, is provided with an opening mask which is employed for manufacture of the conductive regions or passages. The first plate is then subjected to a material removing treatment in order to form the openings in the first plate. A material which is substantially transparent in the visible range of light is subsequently applied to both sides of the first plate. This material, preferably ITO, is firstly used to form the electrodes of the picture elements of the LCD arrangement and secondly to form the conductive tracks and passages for supply of the control signals to the electrodes. The second plate is coated on one side with ITO and structured for formation of the counter electrodes and subsequently affixed to the first plate, spaced apart parallel thereto. A liquid crystal fluid is then filled into the space between the two plates, preferably PDLC.

The transparent material, preferable ITO, is rendered conductive by way of a heat treatment. The coating material, in the case of ITO, is made transparent after the structuring by way of a heat treatment. Initially after the vapor depositing the thin layer is not transparent, but easily etched (HCL). After the tempering (oxidation), it is transparent but only etched with difficulty (hydrofluoric acid). Otherwise, transparent material could of course also be made conductive by a doping or the like. So could, for example, a completely closed material layer or a glass be used directly and doped superficially such that a transparent property and electric conductivity would only be present in the electrode or conductor regions. For example, a masking coating of aluminum oxide (Al_2O_3) on a glass substrate, such as FOTURAN®, could be applied to subsequently introduce a temperature initiated doping or a doping based on bombardment with boron ions or the like such that an electrode or conductor structure is produced. This method has then the advantage that an even structure would be present, whereby however a comparatively high doping would be required to provide the required conductivity. In the case of a doping by way of ion bombardment, optical scatter centers could be created which can lead to

disruptions.

When the first plate is subjected to the material removing transformation to generate the openings for the conductive regions in the first plate, this can be carried out be way of a reactive processing, for example a dry or wet etching. When FOTURAN® is used, etching can be carried out by way of hydrofluoric acid.

Conventional vapor deposition or sputtering technology can be used for the application of the material onto the first and/or second plate, whereby this material is essentially transparent in the visible spectrum. When the first plate is being coated, it can be first coated on one side and then on the other. The coating of the both sides can be carried out sequentially, but gripping arrangements with transmissions, for example planetary drives, are available which are able to carry out a complete surface coating. It is thereby essential that the first plate is rotated at an angle to the vapor or sputtering material source, at about an angle of 35 to 60°, preferably 45°, in order to coat the openings or their walls, whereby also an edge covering between the plate surface and the walls of the openings is essential. The first plate can thereby also carry out a tumbling movement whereby preferably a mean inclination of 35 to 60°, especially 45°, to the vapor or sputtering material source is very advantageous.

As already mentioned above, a cover layer should be applied upon completion of the LCD arrangement according to the invention which is UV reflecting or UV absorbing. This can be in the form of a UV protective glass or in the form of a UV protective foil. After the coating, the openings for the conductive regions in the first plate can be at least essentially filled with at least essentially transparent material. Of course, it is especially advantageous when the openings can be completely filled, since air bubbles or the like can be disadvantageously significant as light scattering centers. A transparent material can thereby be inserted into the openings, heated, and subsequently subjected to a vacuum, so that present or remaining air bubbles can escape because of the low outside pressure.

The UV-reflecting or -absorbing cover layer or the UV-protective glass or the like can be adhered onto the first plate simultaneously with the filling of the openings for the conductive regions using the synthetic resin, putty or the like.

Counter electrodes and feed conductors therefore are formed on the second plate. Since in a preferred embodiment according to the invention a duplex control is maximally possible to achieve the required contrast ratio for the PDLC-LCD arrangements preferred according to the invention, respectively only two picture element electrodes can be controlled with one and the same signal. This allows a reduction to half the number of the required signal feed conductors. For example, for a 20 x 30 matrix from 600 to 300. In place of a single counter electrode, two separate counter electrode systems with different, for a duplex operation suitable signals are then to be controlled.

However, it must be pointed out that other processes can of course be used for the manufacture of the openings in the transparent plate. The required openings, for example, can also be achieved by way of a laser.

Brief Description Of The Drawings

The present invention will be described in the following by way of preferred embodiments which include features according to the invention. With reference to the attached illustrations, further features, objects and advantages according to the invention will thereby be disclosed, whereby:

FIG. 1 shows a construction of an exposure arrangement with an LCD arrangement with features according to the invention in a schematic cross sectional view;

FIG. 2 shows a second exposure arrangement with an LCD arrangement with features according to the invention in a view corresponding to the one of FIG. 1;

FIG. 3 shows a construction of an LCD arrangement with features according to the

invention;

FIG. 3A shows an opening for a conductive region or an electrically conductive passage in an LCD arrangement with features according to the invention;

FIG. 4 shows an electrode plane of an LCD arrangement with features according to the invention;

FIG. 4A shows a portion of the conductor plane of the LCD arrangement according to FIG. 4;

FIG. 5 shows an LCD arrangement according to FIGS. 3, 4, 4A having an additional plane with counter electrodes;

FIG. 6 shows the LCD arrangement according to FIGS. 3 to 5 in top view;

FIG. 6A shows the LCD arrangement according to FIG. 6 in a side view;

FIG. 7 shows switching curves of an LCD arrangement with features according to the invention;

FIGS. 8A to 8E show a control schematic for a picture element pair of an LCD arrangement with features according to the invention; and

FIG. 9 shows a process for the manufacture of an LCD arrangement with features according to the invention.

Detailed Description Of The Preferred Embodiment

Identical or at least functionally identical components are in the Figures normally identified with the same reference numbers. Explanations for one component with a specific reference number are correspondingly also applicable to components of

other Figures which are referred to by the same reference number.

FIG. 1 generally illustrates an exposure arrangement 10 which can include an LCD arrangement 20 with features according to the invention.

Starting from a light source 12, a light beam is directed through a material band of negatives 21 by way of an optical arrangement 14, 16 and along an optical axis 18. The LCD arrangement 20 with features according to the invention is placed before the negative 21.

The LCD arrangement 20 which is shown enlarged at the top right of FIG. 1 includes darkened regions 20b which lead to a larger light scattering so that in this region less light is captured by the lense 22. Conversely, regions 20a are present which are darkened only little or not at all or only over a short time or not at all. Correspondingly, the opposite side 20b of the LCD arrangement 20 can be darkened over a longer time.

The light passing the LCD arrangement 20 subsequently shines through the negative 21 and is projected by the optical arrangement 22 onto print 26 of a band 24 with photo-sensitive material. The curve 28 above the print 26 thereby shows the light intensity across the print 26 when the LCD arrangement 20 is not scattering. The continuous line 30 shows the light intensity when the LCD arrangement, as shown in FIG. 1 at the top right is operated to symmetrically scatter. Correspondingly, the curve 30 corresponding to the light-dark-graduation of the LCD arrangement 20 of the material web 24 or above the print 26 to be exposed is symmetrical or one-sided warped.

A subtractive filter arrangement 32 is positioned in FIG. 2 in the light path 18 behind the light source 12. Subtractive filters for different colours, for example, yellow, magenta and cyan, can respectively be inserted at different degrees into the light path in order to allow the passage of more or less light of a specific colour. The

exposure time with such an arrangement as illustrated in FIGS. 1 and 2 can average about 30 ms, but can significantly differ herefrom depending on whether the picture taken is too light or too dark.

A light guide 16a is furthermore positioned in the light path 18 having a diffusing scrun 16 placed between the walls thereof. This arrangement is used to homogenize the light of the light source 12, which, for example, is a halogen lamp with a helical wire, and which light passes through the subtractive filter arrangement 32. This homogenized light further has the effect that possible scratches on the negative film 21 are only slightly or no longer visible.

Beyond the light guide 16a, an LCD arrangement 20 is again positioned with features according to the invention.

This can be gradually darkened or darkened for a specific time in selected regions. According to the requirements which result from the over or underexposed portions of a negative to be printed.

Finally, an automatically controlled zoom lense 23 combined with a shutter 25 can be provided in order to project the negative, possibly enlarged, onto the print 24.

According to the invention, it is preferred that the LCD arrangement includes a PDLC-material as liquid crystal material, since this allows a significantly better light gain. If another material were used, the light source 12 would have to be upgraded, for example, from 500 watts to about 2500 watts in order to let sufficient light pass. Of course, the exposure time could also be significantly extended, whereby then however a duration per individual exposure of an average 150 ms would decrease the efficiency of a corresponding exposure arrangement so that the photographic copier would hardly be competitive because of its low throughput.

FIG. 3 illustrates a transparent plate 102 of an LCD arrangement 20 with features

according to the invention. This transparent plate which is referred to in the claims as first plate, includes different openings in order to thereby produce conductive regions or passages in the plate 102. The conductive tracks or conductors are guided to the edge of the plate („connector" in FIG. 6), so that later a connection of the matrix by way of „flexiprints" is possible.

The openings 54, 56, 58, 62 have exactly the same function as the central openings 50, which means they function as passages for the (peripheral) electrodes of the LCDs. However, in order to leave sufficient space for the feed conductors (FIG. 4A), they are not (contrary to the central openings) placed over the center of the corresponding picture element pair, but displaced further outwardly. The connections for the peripheral electrodes in FIG. 4 are correspondingly outwardly elongated.

As is apparent, the plate 102 or the opening pattern of the plate 102 is symmetrical to the axis 52a and 52b, whereby in the later operation of an exposure arrangement according to, for example, one of FIGS. 1 or 2, the optical axis 18 of the arrangement extends through the crossing point of the straight lines 52a, 52b.

Later to be provided conductive tracks can of course also have a rounded path, however, it is preferred that they extend essentially straight and parallel to the construction help lines 60, 60a (for this, see also FIG. 4A).

If possible, the openings 50 should have a specific geometrical shape which does not render the coating of the walls of the openings 50 excessively difficult. A typical geometrical shape of an opening 50 is accordingly apparent from FIG. 3A, which shows that the wall is bi-conical so that at a corresponding application angle of a vapour deposited or sputtered material, the walls of the openings are also continuously coated. Of course, one must thereby also ensure that the diameter of the opening 50 at the upper edge is sized such that the edges do not have a shadowing effect during the coating process. Correspondingly, the ratio between

opening diameter and opening length, which means the thickness of the plate 102, must be appropriately adjusted. Because of the wet etching and the specific behaviour of a glass material including a photosensitive silver compound, the opening portions 50a and 50b are respectively conical or have a trapezoid extent so that overall a opening profile with reduced central diameter results.

Correspondingly, the following purely exemplary dimensions can result for a plate 102. The hole diameter can be 0.3 mm, while the hole depth is 0.5 mm, which means the plate 102 is 0.5 mm thick. The region of interest for a control of the light intensity extends over a region which is both smaller than the rectangle defined by the outermost rows of the openings 50 and larger than the rectangle defined by the second outermost rows. For example, an active matrix region can hereby result of about 30 mm in direction of the axis 52b and of about 45 mm in direction of the axis 52a. The spacing of the openings 50 in the active region of the plate 102 can be about 3 mm in direction of the axis 52b, while the spacing between the individual openings 50 in the direction of the axis 52a, for example, can be about 1.5 mm. Possible further dimensions and size relations result from the mentioned exemplary dimensions, since they can be used as an exemplary base for the further dimensions for an exemplary reproduction to scale, also with respect to the FIGS. 4, 4A, 5 and 6.

FIG. 4 illustrates a plane of picture element electrodes 74 on an LCD arrangement 20. The picture element electrodes 74 respectively include about centrally the openings 50 with the conductive regions or passages, which connect the picture element electrodes 74 to the conductor tracks which are positioned on the opposite side of the plate 102. Although the conductive regions or openings 50 are illustrated here centrally to the picture element electrodes 74, they can also be placed differently. The connections 72, 70 are respectively used for connection of one or possibly several picture element electrodes 74. The conductor tracks can thereby be extended to the edge of the plate so that a later connection with the above-mentioned "flexiprints" is made possible.

FIG. 4A illustrates a plane with feed conductors 51, which transmit the signals for the picture electrodes 74 according to FIG. 4 from the connections 70, 72 to the openings or connective regions 50, which then lead through the conductive regions through the first plate 102 (see FIG. 4), to the picture element electrodes 74. The feed conductors 51 should thereby have as large an area as possible in order to subject the light which passes through the LCD arrangement 20 to constant conditions as much as possible. The spacing between the individual picture element electrodes 74 or between the conductors can thereby be adjusted to between 10 µm and 50µm. Manufacturing tolerances on one hand and disadvantages because of electrical short circuits between the electrodes should be avoided in this manner, while at the same time the light passing through the LCD arrangement 20 is not or only slightly negatively influenced.

FIG. 5 shows in addition the plane of the counter electrodes 82, 86 which according to a duplex process are positioned respectively opposite to adjacent picture element electrodes 74 (see FIG. 4). Control of the counter electrodes 82, 86 is carried out through contacts or contact patterns 80, 84. The counter electrodes are thereby provided on a separate plate of transparent material, the second plate (104 according to FIG. 6A).

The different components of the first plate 102 are here also shown because of the transparency of the LCD arrangement according to the invention, however, they are not discussed again, since they have already been described with reference to FIGS. 3, 4 and 4A. FIG. 6 or FIG. 6A show the total components of an LCD arrangement with the different planes according to FIGS. 3 to 5 and in an overall view. A UV-protection plate 100, preferably of glass, covers at least the volume 108 in which the liquid crystal fluid is found. The liquid crystal fluid volume 108 is produced by spacers 106 between the plates 102 and 104. The connections at the edges of the plate 102 are outwardly extended so that the LCD arrangement 20 can be relatively easily contacted by way of clamping plugs or solder contacts or the like. The number of connections is apparent from FIG. 6.

The plate 102 is preferably made from FOTURAN® (trade-mark of the Schott Company). The plate 104 can be made of simple transparent material, for example, a class of high optical quality.

As already mentioned, all electrodes, counter electrodes, feed conductors and so on which are located in the active region of the LCD matrix, which means in the region which is to be used for the manipulation of picture data, should be made of a conductive, transparent material, especially ITO.

FIG. 7 shows the measured relative light intensity in the plane of the photographic paper for three different embodiments of the PDLC liquid crystal and depending on the effective voltage applied across the electrodes. It is apparent that two principally different embodiments are posssible, namely one which has a scattering effect without an applied voltage signal and another wherein the scattering effect increases with increasing effective value of the applied voltage signal. In both cases, the modulation of the light intensity is achieved in that less light is captured by the lense with increasing scattering (see also FIG. 1). The opening angle of the lense used for the measurements is, for example, about 10°.

It is further apparent from FIG. 7 that a change of the measured light intensity (which means the scattering effect) only occurs after a certain value of the effective voltage. This value is referred to in the following as threshold voltage.

FIG. 8 shows a possible manner of control of an LCD with voltage signals which represent an optimal duplex control (see Nehring J., Kmetz A.: "Ultimate Limits for Matrix Addressing of RMs Responding Liquid Crystal Displays", IEEE Trans. Electron. Devices, vol. ED-26, S. 795-802, 1979). In this type of operation, two picture elements are respectively combined to a single electrode, whereby the number of required picture element connections and feed conductors is cut in half.

FIG. 8A shows a pair ("R") of picture elements combined to one electrode.

Obviously, the scatter effect of the liquid crystal in the region of an individual picture element should be possibly be different. This is achieved in that one uses two counter electrodes (Com1, Com2) controlled with different voltage signals on the side of the liquid crystal opposite the picture elements. In reality, further picture element pairs of the same LCD matrix row are placed left and right of the illustrated picture element electrode "R", which are all placed over the same pair of counter electrodes Com1 and Com 2. All further rows of the LCD matrix use counter electrode pairs which are controlled by the same voltage signals as Com1 and Com2 (see therefore FIG. 5). FIG. 5B shows the periodic voltage signals placed on Com1 and Com2 (only one period of these signals is shown which extends over six time intervals).

FIG. 8C (left) shows four different voltage signals, which can be selectively placed on the picture element electrode. For understanding of the duplex process, the signals are best imagined as periodical, although, as explained further below, the four illustrated signals can be combined in a suitable series for the achievement of grey shades. The voltage difference resulting across the liquid crystal and actually in a first approximation its effective value (root of the square of the mean), determines the light modulation effect. The resulting voltage differences are shown in FIG. 8D they are, of course, different depending on whether the corresponding picture element is over the counter electrode Com1 or Com2.

The Table of FIG. 8E shows that in fact four conditions are possible with this control process. The effective voltage over the liquid crystal can selectively be Uo or 3Uo for each of the two picture elements. Most sensibly, Uo is selected to be about equal to the threshold voltage of the liquid crystal (FIG. 7) so that the voltage modulation factor of 3 can be translated into the largest possible intensity modulation factor (contrast).

The threshold voltage of liquid crystals is temperature dependent (it decreases with increasing temperature). If the effectiveness of the LCD matrix is to be maintained

over a large temperature range, it is sensible to control or regulate the amplitudes of the voltage signals (which means Uo) depending on the temperature. This type of duplex control can achieve the largest possible voltage modulation factor.

This factor decreases with increasing order of the multiplex (which means with increasing number of picture elements which are combined to one electrode). For this reason, and because of the relatively flat course of the characteristic line of PDLC liquid crystals, a multiplex of the order 2 (duplex) is preferably used.

It is apparent from FIG. 8C that tertiary signals are required for the control of the picture element electrodes. The electronic circuitry for the generation of the signals can however be significantly simplified when binary signals are used instead. A possible control with binary signals is described in Appendix A. However, this simplification is achieved to the detriment of the voltage modulation factor which then is only $1+\sqrt{2}$ instead of 3. The described method allows it to place each picture element into one of two conditions (on and off). Although the aesthetic appearance of photographic copies can also be improved with a purely binary LCD matrix, the quality can be significantly improved by the use of intermediate values (grey shadings). Grey shadings can be achieved in different ways with the described control method. The two most advantageous are:

- Variation of the ratio T_{on}/T_{off} within the exposure interval $T_B = T_{on} + T_{off}$. Use is here made of the fact that the photographic paper integrates the (variable) light intensity over the whole exposure interval T_B.
- Temporal multiplexing of the four different picture element electrode signals. A periodic control can so be used, for example, which base period is made of, for example, 16 partial sequences, which can selectively correspond to one of the four signal forms illustrated in FIG. 8C. If the duration of the base period is sufficiently small, the liquid crystal thereby reacts to the effective value of the compound signal, and 16 grey shades can be achieved for each picture element.

The steps of a manufacturing process for an LCD arrangement with the features according to the invention are apparent from FIG. 9. Furthermore, quality and properties test steps are apparent from this Figure. In step 121, a FOTURAN®-glass plate, a UV-protective glass in the form of a cover glass and a base plate for the cover electrodes are provided for the manufacture of an LCD arrangement with features according to the invention.

A mask is applied to the FOTURAN®-plate and structured so that a hole mask results which is used for the manufacture of the conductive regions or passages. Subsequently, a UV-irradiation is carried out to which the photosensitive silver composition within the glass reacts. The FOTURAN®-plate is subsequently tempered. Etching with hydrofluoric acid is then carried out to create the openings 50 in the plate 102.

A chrome Quartz mask can be used, for example, as the irradiation mask for the FOTURAN®-glass. Otherwise, manufacturing guidelines or processing guidelines as published by the manufacturer must be followed, for example, also in the information prospectus "FOTURAN® - Ein Werkstoff für die Mikrosystemechnik" of the Company Schott, published 1995, which is expressly made part of the disclosure of the present application.

After completion of the FOTURAN®-hole plate 50, the various components of the LCD arrangement with features according to the invention are optically or visually tested in step 122. If errors are observed, one tries to improve the components or to provide other components.

In step 123, the FOTURAN®-hole plate is polished or its surface optically treated.

Subsequently, in step 124, a coating is placed onto the FOTURAN® glass. This coating consists of a material known under the designation ITO (indium tin oxide).

In order to be able to test the quality of the coating, test glasses are also coated. A testing of the coating takes subsequently place in step 125. This tests, among other things, the optical quality of the coating. Subsequently, the ITO coating which was applied onto the also coated test glasses is tempered in order to render the responsible components in the ITO coating conductive and transparent. The test glasses are subsequently tested once again, by measuring the conductivity, which means, their surface resistance is tested. Furthermore, the transparency of the glasses in connection with the ITO coating is tested. If the test provides satisfactory results, the hole plate or base plate which, so far, has not been tempered, is structured, which means conductor electrodes or counter electrode structures are formed in the ITO coating by way of photographic techniques (photo lacquer structure, developing, etching or the like).

The tempering of the ITO coated portions of the LCD arrangement with features according to the invention follows subsequently in step 129.

A test of the essential properties or components is again carried out in step 130. A visual inspection, a resistance measurement, the checking of the connectors and electrodes and a checking of the quality of the electric connections between the various electrodes and connectors is carried out. When all tests and measurements are satisfactory, a cover glass is placed onto the arrangement in step 133 before the hole plate and the base plate are connected with one another by way of a spacer. The cover glass consists of UV-absorbing or -reflecting material and protects the volume which is intended for receiving the liquid crystal fluid from UV-irradiation which could damage the liquid crystal. For fastening of the cover glass in step 133, a synthetic resin or putty or the like is used so that the remaining openings in the FOTURAN® hole plate are filled with transparent material. Another check is subsequently carried out in step 134 in order to determine whether air bubbles remain in the openings. If air bubbles remain, it is possible that this LCD arrangement cannot be used to carry out perfect control of the projection of a negative onto a print.

If the test in step 134 has shown that the quality of the essential properties of the intermediate product is satisfactory, the liquid crystal is filled into the space for the liquid crystal, the space sealed and the contacts connected.

Finally, further visual inspections are carried out in step 136 and measurements are carried out to test whether the final product with its essential properties lies within the tolerance limits.

If an error is detectable in step 125 during the optical testing, one can only polish or treat the glass by removing the ITO coating by way of material removing techniques, such as polishing. The same is also possible in step 127. One can there also return to step 123 in order to completely remove the eventually unsuccessful ITO coating. The same applies to step 130. The structured electrodes and connectors, as well as feed conductors can here also be removed by polishing of the FOTURAN® hole plate. Feed conductors outside the active LCD matrix can possibly also be repaired by hand which is indicated by step 132.

After finishing in step 135, the final product is installed into an exposure arrangement according to FIGS. 1 or 2. Step 138 only symbolizes the disposal of an insufficient final product or intermediate product.

Regarding the attached Appendix A, it needs only be mentioned that it represents the control process for a duplex control of the LCD arrangement according to the invention. It is practically only a control system expressed in software terms (in the programming language "Maple"), which process is self-explanatory from Appendix A. Since programming languages are in the English language, the comments in Appendix A are also written in the English language.

With the LCD arrangement according to the invention, it is possible to achieve light yields of about 60% of the incoming light. Even higher values are achievable. Furthermore, colour distortions are significantly less than in conventional LCD

arrangements which provide only a light yield of about 20%.

CLAIMS

1. LCD arrangement especially for the exposure control of an exposure arrangement, such as a photographic printer, for the exposure of photosensitive material, comprising

a) a first transparent plate and a second transparent plate which are planar and positioned spaced apart parallel;

b) a liquid crystal fluid which is enclosed between the plates;

c) a plurality of picture elements (pixels);

d) electrodes provided on the first and second plates and associated with the picture elements;

e) feed conductors for feeding control signals to the electrodes;

f) the electrodes associated with the picture elements being located on one side of the first plate;

g) the feed conductors associated with the electrodes being located on the other side of the first plate; and

h) the respective feed conductors being connected with the electrodes through conductive regions in the first plate.

2. LCD arrangement according to claim 1, further including a plane of counter electrodes separate from the electrodes.

3. LCD arrangement according to claim 1, wherein the conductive regions are openings in the first plate, the edges or walls of the openings being at least partly covered with a conductive material.

4. LCD arrangement according to claim 2, wherein at least one of the electrode or counter electrode planes are made of a material which at least in the visible light spectrum is at least substantially transparent.

5. LCD arrangement according to claim 1, wherein at least some of the feed

conductors or feed conductor planes which are associated with the electrode planes are made of a material which at least in the visible light spectrum is at least substantially transparent.

6. LCD arrangement according to one of claims 4 or 5, wherein the transparent material is also conductive.

7. LCD arrangement according to claim 6, wherein the material is indium in oxide.

8. LCD arrangement according to claim 1, wherein the first plate includes a radiation sensitive additive, so that the conductive regions or passages can be manufactured by appropriate treatment.

9. LCD arrangement according to claim 8, wherein the additive is a silver containing additive.

10. LCD arrangement according to claim 1, wherein the first plate is made of FORTURAN® glass.

11. LCD arrangement according to claim 8, wherein selected regions have been irradiated and subjected to a material removing operation to produce the openings.

12. LCD arrangement according to claim 11, wherein the regions are subjected to wet etching.

13. LCD arrangement according to claim 1, wherein the conductive regions in the first transparent plate have been provided by doping.

14. LCD arrangement according to claim 1, wherein the area of the feed conductors is as large as possible, at least in the active matrix region of the LCD arrangement.

15. LCD arrangement according to claim 1, wherein an area of each electrode is as large as possible, at least in the active matrix region of the LCD arrangement.

16. LCD arrangement according to claim 2, wherein an area of each counter electrode is as large as possible and, accordingly, an area of the feed conductors is as large as possible, at least in the active matrix region of the LCD arrangement.

17. LCD arrangement according to claim 1, wherein the openings are filled as much as possible with a substantially transparent film material selected from the group of synthetic resin, mastic and putty.

18. LCD arrangement according to claim 1, wherein UV-protection is applied to at least one of the first and second plates.

19. LCD arrangement according to claim 2, wherein each counter electrode region is respectively associated with two electrode regions of two picture elements of the LCD arrangement.

20. LCD arrangement according to claim 1, wherein the picture element is exposed to one of analog and binary AC-signals.

21. LCD arrangement according to claim 1, further including a colour selective filter arrangement for separately selectively exposing a print material for each of the colour ranges for which the print material has a sensitivity.

22. Process for the manufacture of an LCD arrangement according to claim 1, including the steps of

a) providing the first plate with an opening mask for defining the conductive regions;

b) subjecting the first plate to a material removing treatment for producing the openings in the first plate;

c) applying a material which in the visible light spectrum is essentially transparent to both sides of the first plate;

d) structuring the conductive, transparent material for forming at least one of the feed conductors and the electrodes;

e) fastening the second plate planar and spaced apart parallel to the first plate; and

f) filling an intermediate space between the plates with the liquid crystal fluid.

23. Process according to claim 22, comprising the further step of rendering the transparent material conductive by one of temperature treatment and doping.

24. Process according to claim 22, wherein a reactive processing is carried out in step b).

25. Process according to claim 24, wherein the reactive processing is wet or dry etching.

26. Process according to claim 22, wherein step c) comprises vapour deposition or sputtering technology, whereby both sides are coated sequentially or simultaneously.

27. Process according to claim 26, wherein the first plate is rotated at an angle of inclination relative to the vapour deposition or sputtering material source of 35 to 60°, in order to coat the wall of the openings.

28. Process according to claim 27, wherein the angle of inclination is 45°.

29. Process according to 27, wherein the first plate carries out a tumbling movement, and the mean angle of inclination is adjusted to be about 45°.

30. Process according to one of claims 22, wherein a cover layer is applied to the first plate.

31. Process according to claim 30, wherein the cover layer is a UV-protective glass.

32. Process according to claim 22, wherein the openings after the coating are at least substantially filled with an at least substantially transparent material.

33. Process according to claim 22, characterized in that the openings after the coating are at least essentially filled with an at least substantially transparent material, whereby the cover layer is affixed to the first plate by way of the transparent material.

34. Process according to claim 22, wherein the counter electrodes and feed conductors are formed on the second plate.

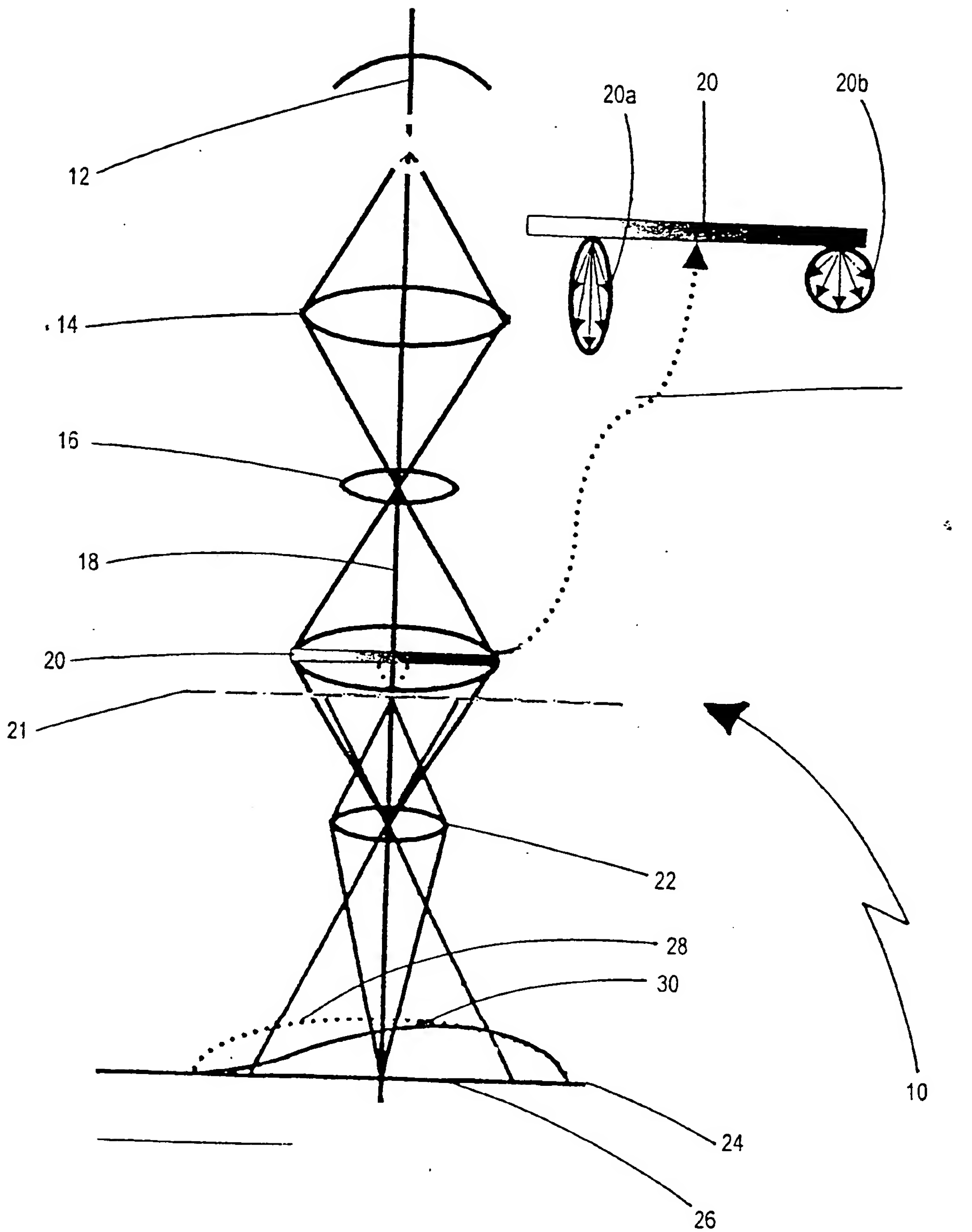


FIG. 1

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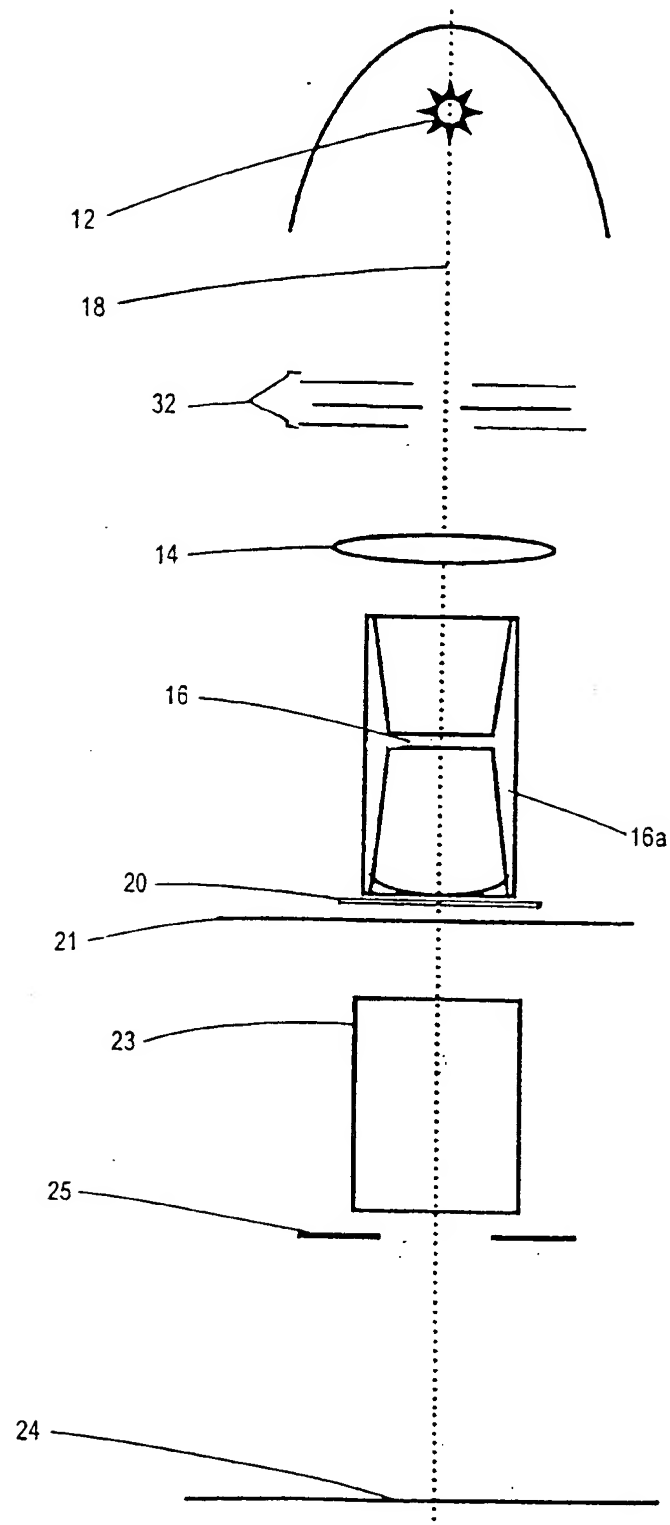

FIG. 2

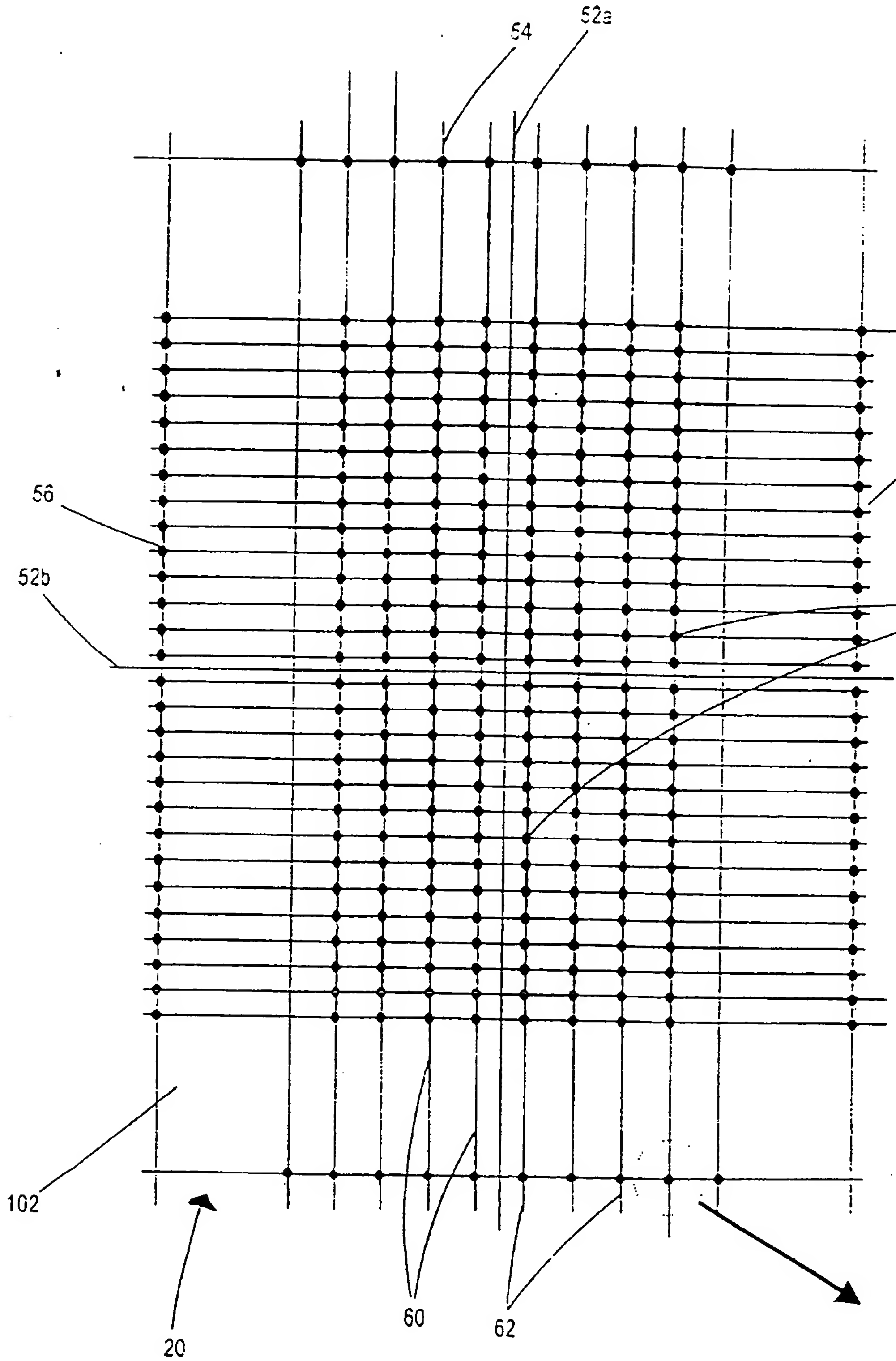

FIG. 3

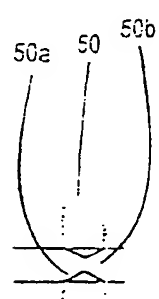

FIG. 3A

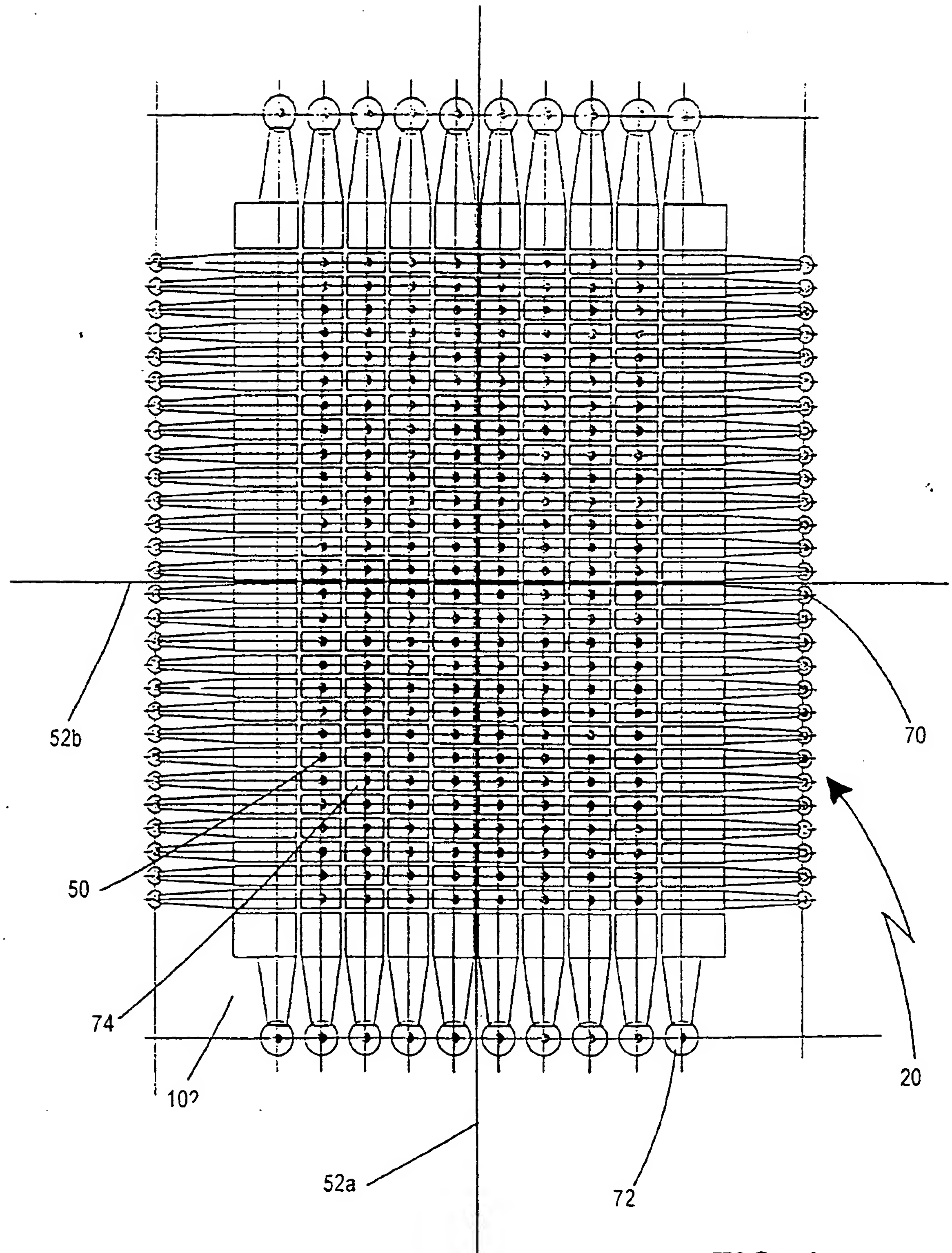

FIG. 4

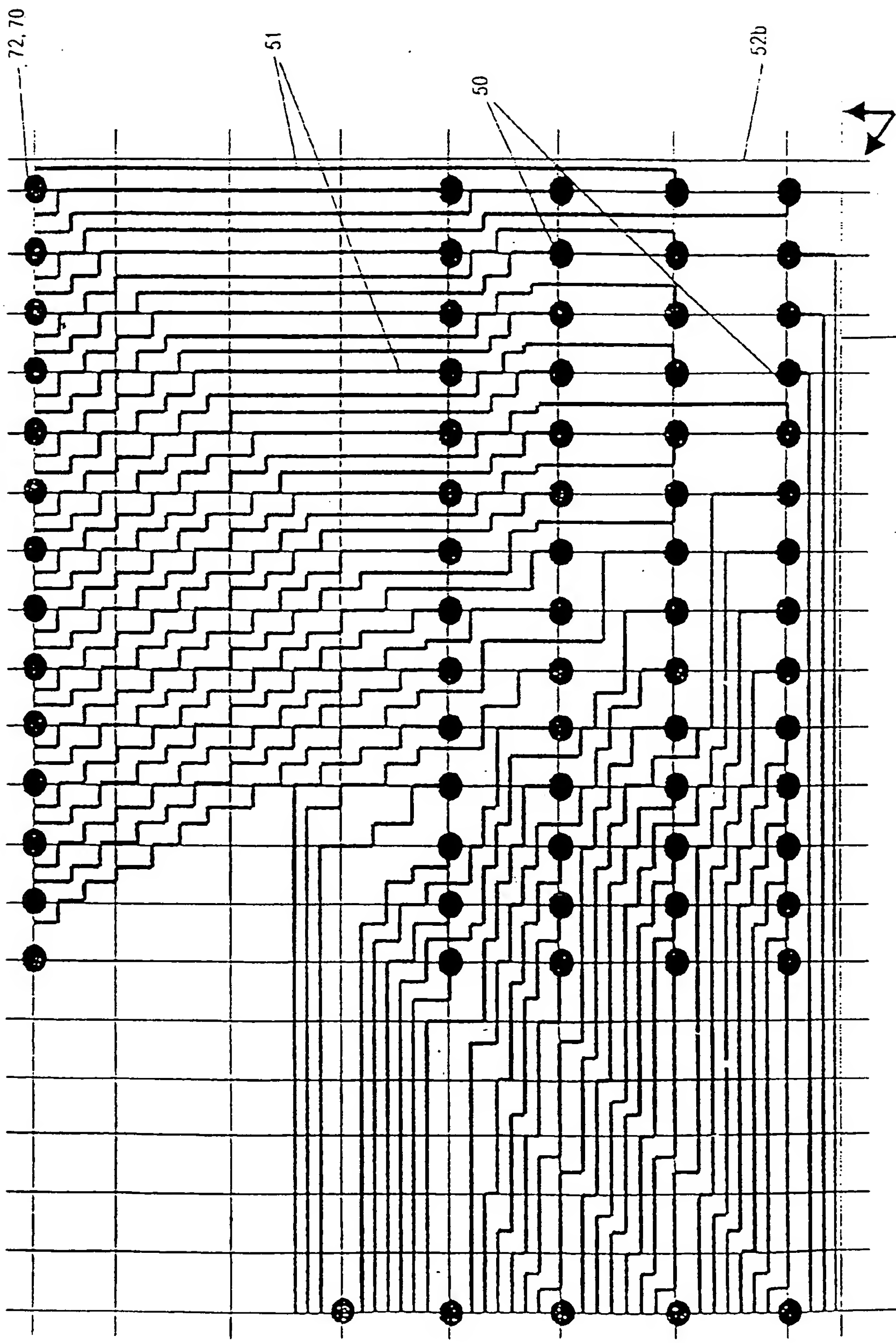

FIG. 4A

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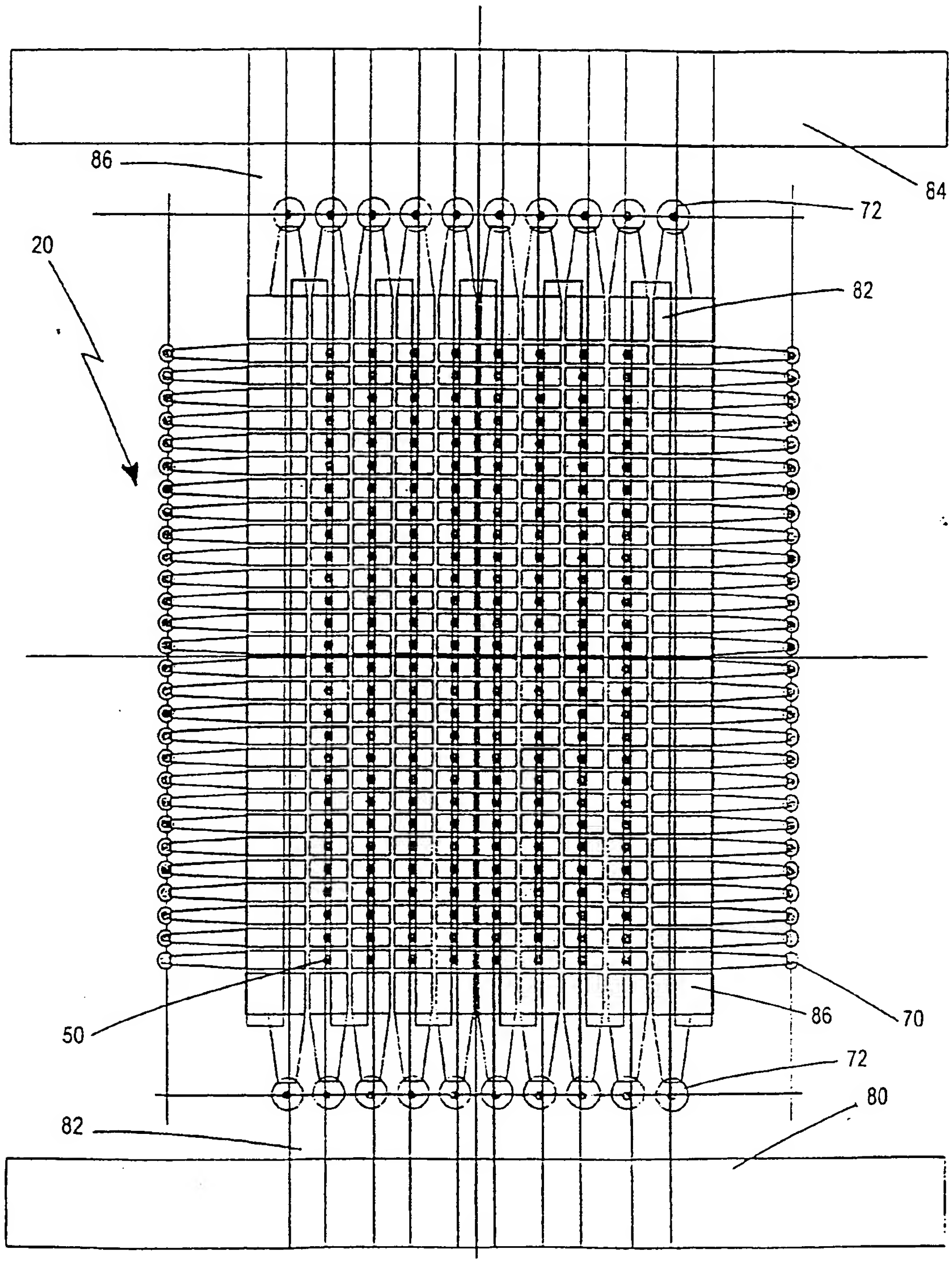


FIG. 5

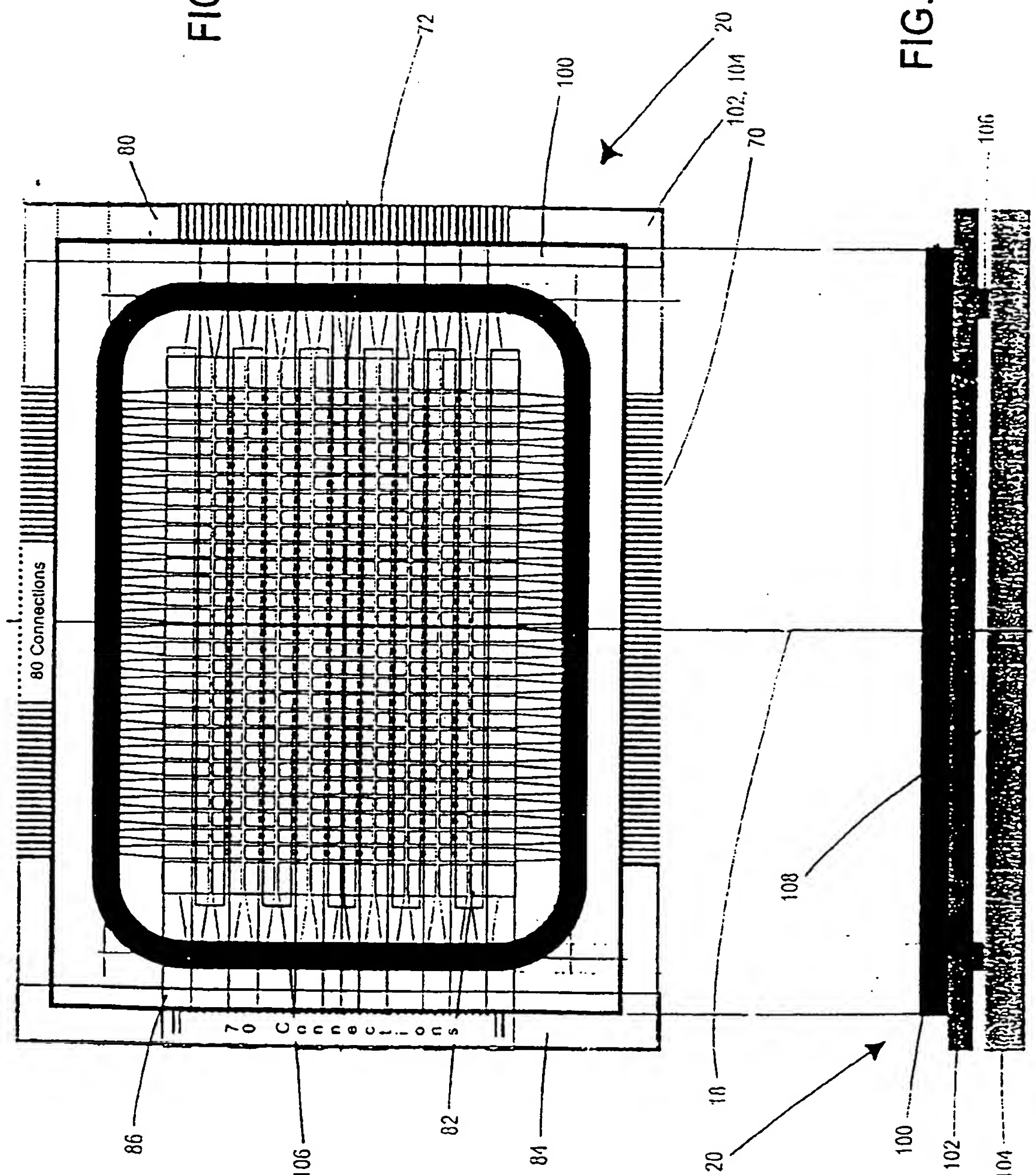
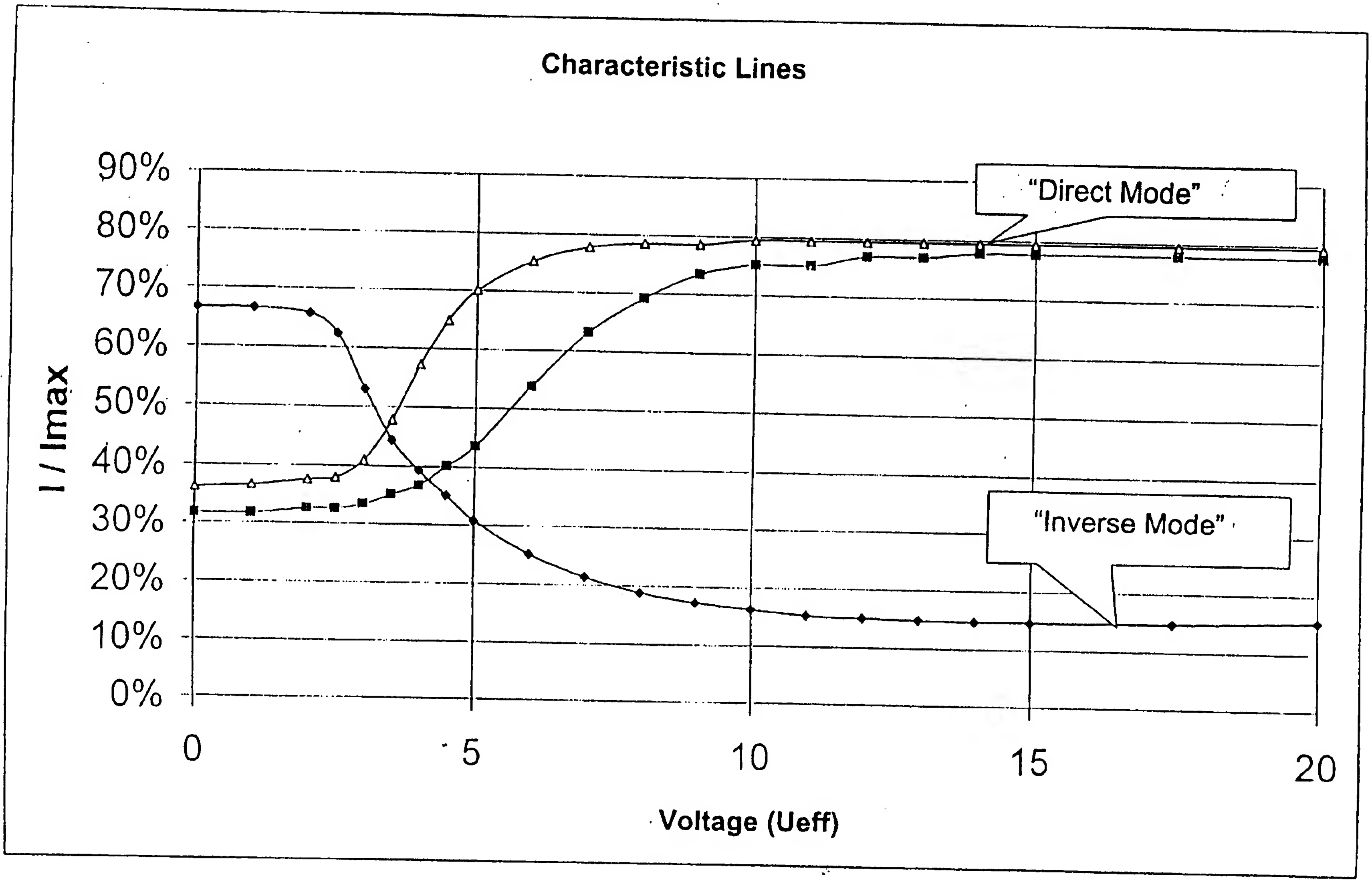

80 Connections
70 Connections
72
80
100
20
102, 104
70
106
108
86
106
82
84
18
20
100
102
104

FIG. 6

FIG. 6A

FIG. 7



Characteristic Lines
I / Imax
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5
10
15
20
Voltage (Ueff)
"Direct Mode"
"Inverse Mode"

FIG. 8

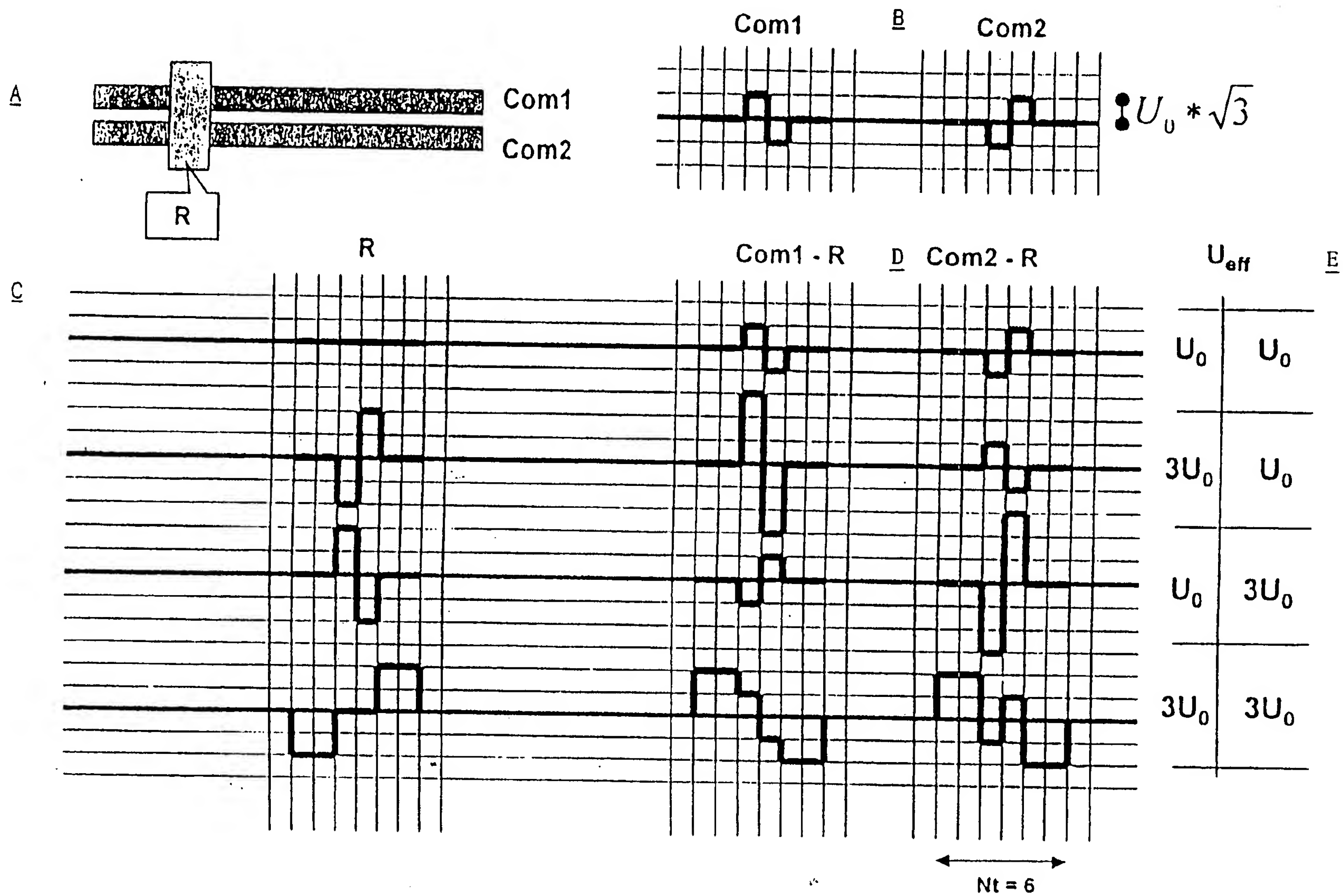
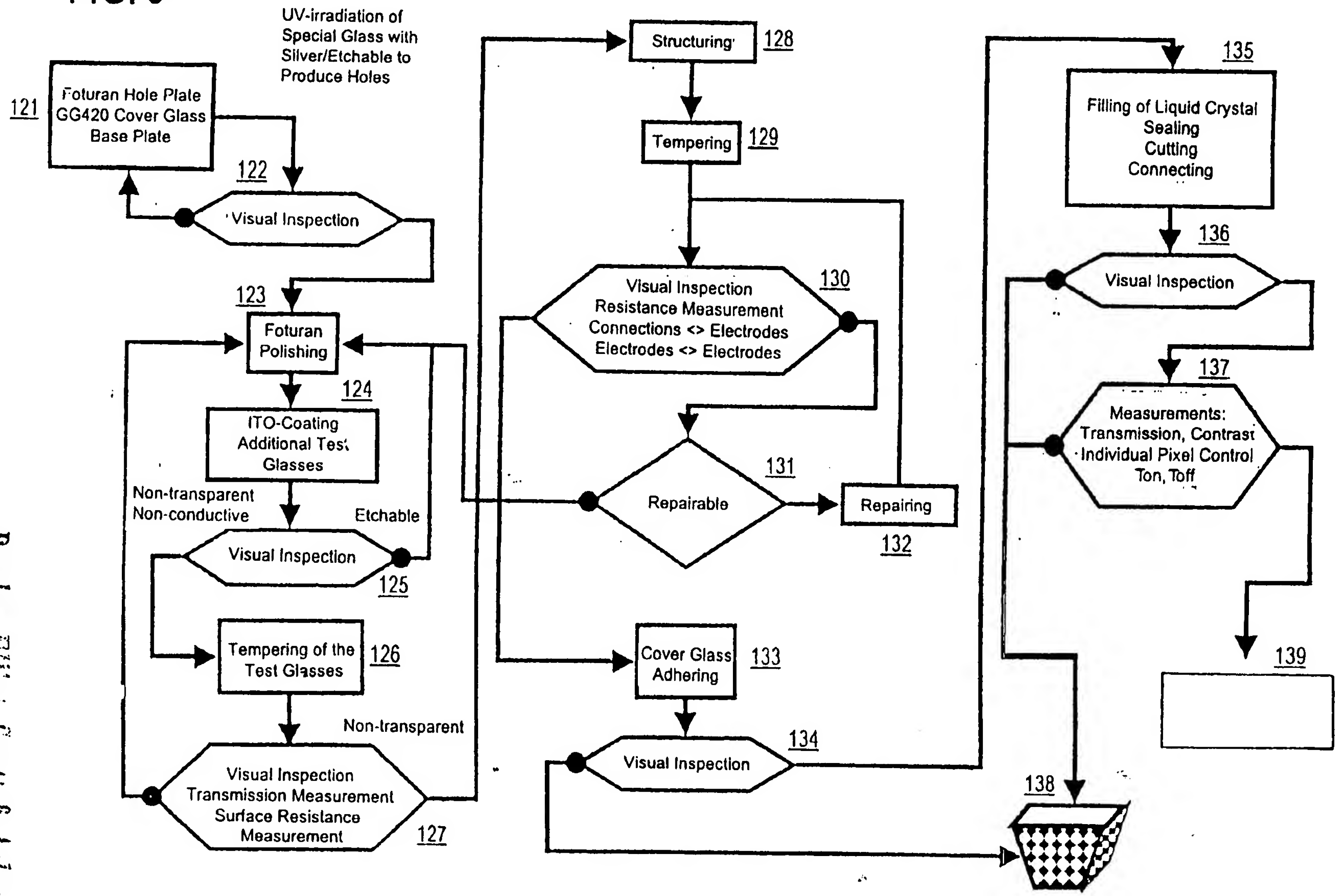

A
Com1
Com2
R
B
Com1
Com2
$U_0 * \sqrt{3}$
C
R
Com1 - R
D
Com2 - R
U_{eff}
E
U_0
U_0
$3U_0$
U_0
U_0
$3U_0$
$3U_0$
$3U_0$
Nt = 6

FIG. 9



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